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Supernovas

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Abstract

Supernova explosions are shown to be core explosions, caused by the separation of charge. Electrons separate the charge by expanding through the mass, not into it. This eliminates mathematical constructs that rely on electron pressure, such as the Chandrasekhar limit, as a consequence. It appears core explosions form solar systems.

Keywords

Supernova Explosions, Core Explosions, Charge Separation, Electron Expansion, Solar System Formation

1. Introduction

Supernovas are well-known, visible explosions in space, observed and studied for hundreds of years. However, the mechanism of explosion is not well understood. This argument describes a mechanism, producing core explosions in massive stars (supernovas). A benefit of such a mechanism may be the production of solar systems, providing motivation to explore this line of thinking.

Core explosions are proportional to the mass. The higher mass explosions you see, aren't the only ones that exist. There are many lower mass explosions.

Further, core explosions leave no central remnant, no heat source. This allows a produced cloud (the remnants) to re-collapse. Then supernovas produce both requirements for solar systems, the elements and the collapsing cloud.

The argument for core explosions is based on charge. High densities in stars cause electrons to become degenerate. In contrast to current theory, we assume electrons expand through the mass, not into it. This separates the electrons from the ions (the mass), leaving behind a net positive charge. It is the positive charge that supports the star, not the electrons.

Higher densities mean higher energy electrons, resulting in neutronization. A high rate of neutronization will remove charge and collapse the core. Since neutronization is related to higher energy and density, enough unconverted mass remains to explode the star.

2. Degenerate Electrons

It is a common assumption that compact objects, such as white dwarfs, resist gravitational collapse primarily through electron degeneracy pressure. But the gravitational mass is always in the form of an ion gas of some density. Then what prevents electrons from expanding radially through the space between the ions?

Say the density of a white dwarf is 10^{10} kg/m^3, near neutronization. With the radius of a carbon atom around 10^{-15} meters, the area of space for the electron to expand into, is 100,000 times greater that the area of the ion. Most electrons are unobstructed. If the electrons are under pressure, why would they not expand into empty space?

The actual behavior of electrons in compact objects may be analogous to conduction electrons. Aren't electrons modeled as a Fermi gas in a conductor? Do the copper ions present an obstacle to the electrons, prevent them from conducting? At any rate, the behavior of electrons in a star is presumed similar to the electrons in the conductor. They move through the ions as a fermi gas. The following paragraph explains the proposed behavior.

Degenerate electrons do not support the mass of a star, at least not directly. They expand through the mass, to a state of lower energy and larger volume. The electrons are restrained by the positive charge left behind, defining the new volume at some point of equilibrium, which is the lowest energy state for the electrons. The electron "container" is electrostatic, not physical. The ions are not influenced physically by the electrons. They simply occupy a space unavailable to the electrons.

So what does support the mass of a star? The positive charge of the ions. The ions expand (like charges repel) to fill the new volume of electrons, but are suppressed by the gravitational mass. This explains observations of larger, more luminous white dwarfs, larger than expected due to the mass limit (incorrectly) placed on these objects.

Finally, the pressure term for degenerate electrons cannot be used in the equation that describes stars, the equation for hydrostatic equilibrium, which has major consequences for the interpretation of compact objects, like white dwarfs. For one, the mass limit for stars (the Chandrasekhar limit) disappears, it never existed.

Supernovas are now simple and explainable. The path to explosions is a continuous process with the magnitude proportional to the mass. But supernovas are more than just fireworks. We explain briefly how supernovas may contribute to solar system formation in the discussion below.

3. Energy

A comparison of available energy sources shows charge as a possible mechanism for supernovas. To cause an explosion, the coulomb potential of the charge to repel must be greater than the gravitational potential of the mass to assemble. As an example, we place the mass of the sun (iron, say and $M = 2.0\text{e}^{+30}$ kg) into the volume of the earth ($R = 6378.1$ km). The gravitational energy is:

$$(3/5)GM^2/R = 2.5\text{e}^{+43}\ \text{Joules}. \tag{1}$$

The coulomb energy is:

$$(3/5)k(Ne)^2/R = 1.3\text{e}^{+79}\ \text{Joules}. \tag{2}$$

where N is the number of protons ($M/2m_p = 6.0\text{e}^{56}$). To achieve equilibrium with gravity, $N = 1.0\text{e}^{39}$, a very small fraction of the available protons.

4. Lane Emden

We can use the Lane-Emden equation to simulate parameters of a star. If $m = m(r)$ is the mass inside r and $\rho = \rho(r)$ is the density at r, then the hydrostatic equilibrium equation can be written as

$$\mathrm{d}p/\mathrm{d}r = -Gm\rho/r^2 \quad \rightarrow \quad \frac{1}{r^2}\frac{\mathrm{d}}{\mathrm{d}r}\left(\frac{r^2}{\rho}\frac{\mathrm{d}p}{\mathrm{d}r}\right) = -4\pi G\rho \tag{3}$$

with

$$\mathrm{d}m/\mathrm{d}r = 4\pi r^2\rho \tag{4}$$

We introduce two new variables defined by

$$\rho = \rho_c\theta^n, \quad \xi = r/\alpha \tag{5}$$

where ρ_c is the central density of the star and a is a constant defined by

$$a^2 = (n+1)K\rho_c^{\frac{1}{n}-1}/4\pi G \tag{6}$$

The standard form of the Lane-Emden equation is then [1]

$$\frac{\mathrm{d}}{\mathrm{d}\xi}\left(\xi^2\frac{\mathrm{d}\theta}{\mathrm{d}\xi}\right) + \theta^n\xi^2 = 0 \tag{7}$$

with the boundary conditions

$$\theta(\xi = 0) = 1, \quad \left.\frac{\mathrm{d}\theta}{\mathrm{d}\xi}\right|_{\xi=0} = 0 \tag{8}$$

5. Fractional Charge

Separation of charge determines the state of the star. A small separation maintains a steady state, a large separation creates explosions. We can determine between the two by defining a fractional charge. The fractional charge converts the charge into an equivalent mass, as shown below.

The distribution of charge in a star is not a new idea, we list a few papers below [2]-[4]. Observations of luminous supernova led to the idea of more massive white dwarfs to explain them, more massive than the ordinary Chandrasekhar limit ($\sim 1.4M_{\text{sun}}$). Assume the additional mass is supported, in part, by charge.

To model the charge, a coulomb term is added to the right side of Equation (3) above and factored into the Lane-Emden equation. The charge density in the coulomb equation can be modeled proportional to the mass or Gaussian. Here, we simply duplicate the proportional method in ([2], section A) to demonstrate, then calculate the charge directly in the next section.

First, add the coulomb term to the right side of Equation (3):

$$dp/dr = -Gm\rho/r^2 + KQ\rho_c/r^2 \tag{9}$$

If charge and mass are integer multiples of basic units q and m_p, then $Kq^2 = \beta G m_p^2$, where $\beta = 1.24{*}10^{36}$ is dimensionless. And if some integer times this equivalent mass is some fraction, f, of the actual mass, then

$$\mathrm{d}p/\mathrm{d}r = -Gm\rho/r^2(1-f\beta) \tag{10}$$

$$\frac{1}{r^2}\frac{\mathrm{d}}{\mathrm{d}r}\left(\frac{r^2}{\rho}\frac{\mathrm{d}p}{\mathrm{d}r}\right) = 4\pi G\rho(1-f\beta) \tag{11}$$

and

$$a^2 = (n+1)K\rho_c^{\frac{1}{n}-1}\Big/4\pi G(1-f\beta) \tag{12}$$

Now the radius of a white dwarf is defined by $R = a\xi_1$ and the mass of the star, $M(r)$, is obtained as follows:

$$M(R) = \int_0^R 4\pi r^2\rho(r)\,\mathrm{d}r \tag{13}$$

$$= 4\pi a^3\rho_c\int_0^{\xi_1}\xi^2\theta^n\,\mathrm{d}\xi \tag{14}$$

$$= 4\pi a^3\rho_c\xi_1^2\left|\theta'(\xi_1)\right| \tag{15}$$

The author notes when the index $\gamma = 4/3$ (or $n = 3$), the mass is independent of ρ_c - ρ_c cancels out, and the mass has a maximum, the Chandrasekhar Limit always. Adding charge, assigning some value to f, changes this maximum value, as shown in **Figure 1**.

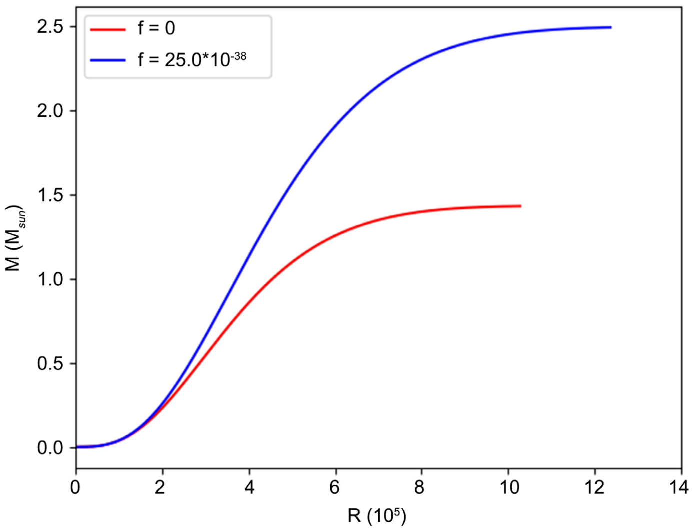

Figure 1. Lane Emden plot showing mass distribution ending with maximum mass. Red (f = 0) with zero charge reproducing Chandrasekhar limit. Blue (f = 25.0 × 10^{-38}) with charge increases the maximum limit. A fixed central density $\rho_c = 1.9\times10^{13}$ kg/m^3.

Higher values of f show higher values of maximum mass. In fact, infinite mass can be supported (over infinite radius) the closer $(1-f\beta)$ gets to zero in Equation (12) (used in Equation (15)). The equations fail if the influence of the charge generated exceeds that of the mass ($f>1/\beta$), and it doesn't take much.

Note these calculations are incorrect (the Chandrasekhar limit is incorrect) because the author uses the electron pressure in Equation (11). Electron degeneracy pressure is not the source of support for the mass in a white dwarf. We simply want to demonstrate the influence of fractional charge over gravity, which should be a general result.

However, we retain the density profile out of convenience. Whatever profile is used is treated the same. We now show how charge is actually generated in a white dwarf star.

6. The Formation of Charge

Matter in compact objects, such as white dwarf stars, can become dense enough for electrons to attain degeneracy, become a degenerate gas. A property of the gas is a Fermi pressure that expands the electrons radially, through the mass, not into it. Therefore, it is not the pressure from electrons that support the mass of the star.

The expanding electrons leave behind a net positive charge. The positive charge (the ions) tries to expand into the space now occupied by the electrons, but is damped by the gravitational mass. If the charge is greater than the gravitational mass, the charge (or star) expands to a point where it equals the gravitational mass and stops, always short of the volume occupied by the electrons. As a result, a net positive charge always supports the mass to some degree.

This mechanism could be harmonic (oscillatory). But we assume as the star cools, the increase in density is so slow, that the system is always in a steady state. However, a star subject to an impulse (from a collapse) will separate the charge, enough to cause an explosion. We want to compare the steady state charge to the maximum charge after an impulse, to demonstrate the mechanism. The equations and plots below make this clearer.

As a reference, model the ions as an ideal gas, carbon ions in this case. Assume the pressure of the ideal gas is equal to the gravitational pressure, at least to begin. Set the temperature at $T = 7.0 \times 10^6$ deg. Then, assuming the temperature is constant throughout the degenerate gas, we have:

$$P_{gas} = K_c \rho, \quad \text{where } K_c = kT/12m_h \tag{16}$$

This will be used to calculate the (low) number of charges in the steady state, where $P_{gas} = P_{gravity}$ below. This is reasonable if the density of the ion gas is close to the density of the expanded ion gas.

To find the maximum charge, divide the star into shells. Assume the ions stationary. (This simulates an impulse, explained later.) The change in Fermi pressure in the current shell will displace electrons radially. Electrons collecting at the Fermi radius seems reasonable, assuming all available states inside this radius are occupied. This creates a coulomb pressure, with N, the number of charges displaced and A_{f}, the area at the fermi radius:

$$P_e = K\left(N/A_f\right)^2, \quad \text{where } K = 12\pi K_q\left(q^2\right)/5 \tag{17}$$

We can model this distribution, solve for N (N_- or N_+), by equating the difference in Fermi pressures caused by the displaced electrons, or $\Delta P_{Fermi} = -P_e$. The Fermi pressure in the current shell, P_{F_1}, changes with number density as the electrons expand, from n_{1a} to n_{1b}, say, as follows:

$$P_{F_{1b}} = \left(hc/4\right)\left(3/8\pi\right)^{1/3} n_{1b}^{4/3} \tag{18}$$

$$= K_F\left(\left(N_{F_1} - N\right)/V_{F_1}\right)^{4/3} \tag{19}$$

$$= P_{F_1}\left(1 - N/N_{F_1}\right)^{4/3} \tag{20}$$

$$= P_{F_1}\left(1 - \left(4/3\right)N/N_{F_1}\right) \quad \left(1^{\text{st}} \text{ order}\right) \tag{21}$$

$$= P_{F_1} - \left(4P_{F_1}/3N_{F_1}\right)N \tag{22}$$

Then solving for N,

$$\left(K/A_f^2\right)N^2 - \left(4P_{F_1}/3N_{F_1}\right)N + P_{F_1} = 0 \tag{23}$$

There are two volumes to consider at this point. There is the original volume, before the expansion of the electrons at r_1, which now contains the positively charged mass. And a second larger volume containing the electrons after the expansion at r_2, say. The expansion of the positive mass is immediate, but inhibited by the gravitational mass (damped). The system is harmonic, but would never oscillate, never exceed r_2. The reason is we assume the change in density of the star is much slower than the expansion of the mass, in most cases. And the mass much slower than the expansion of the electrons, considered instantaneous.

As a result, the system (a white dwarf) is always in a type of steady state. The volume of the mass (positive charge) is almost equal to the volume occupied by the electrons (discussed next), with a relatively low number of charge. However, after an impulse or collapse, the volumes are unequal, represented by r_1 and r_2 in the last paragraph. Then N is very large, enough to cause an explosion.

Continuing, if the volume of the positive ions (the mass) is close enough to the volume of the electrons to consider them equal (call this distance r, now), then the coulomb pressure is found from,

$$P_+ = K\left(N/A_r\right)^2, \quad \text{where } K = 12\pi K_q\left(q^2\right)/5 \tag{24}$$

And for a steady state (a white dwarf), the final number of charge, N_f, is found by equating the pressures of the charge to the gravitational mass ($=P_{gas}$), see Equation (16)),

$$N_f = A_r\sqrt{P_{grav}/K} \tag{25}$$

A profile of pressure for a white dwarf ($\rho_c = 10^{10}$ kg/m³) is plotted in **Figure 2**. The large coulomb pressure (blue, using N in Equation (23), never realized in a white dwarf, always adapts to the pressure of the gravitational mass (green, using Equation (16)) if the positive charge is allowed to expand. As a result, it is the positive charge that supports the gravitational mass.

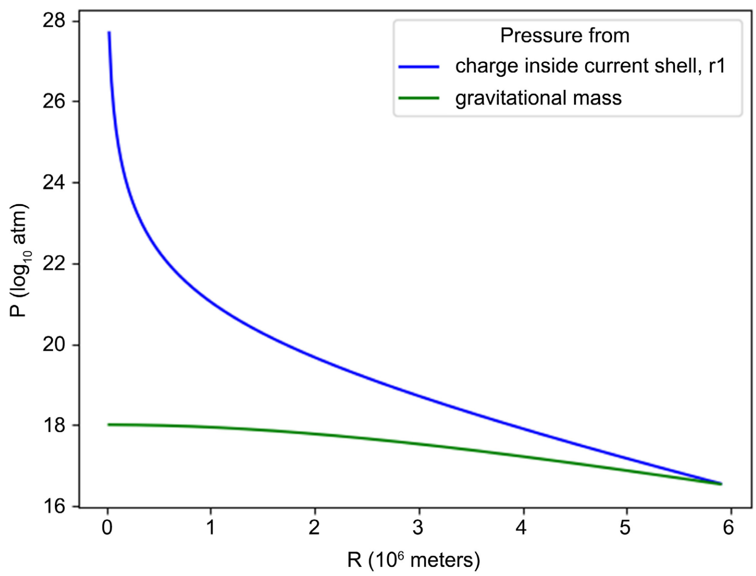

Figure 2. Plot showing the pressure of: the positive charge in the current shell (blue), the gravitational mass (green). The pressure of the positive charge always adapts to the pressure of the gravitational mass, equal and opposite ($\rho_c = 10^{10}$ kg/m^3).

A plot of the fractional charge is shown in **Figure 3**. The enormous positive charge possible (blue, using N in Equation (23)) always adapts to the amount of charge needed (red, using N_f in Equation (25)) to support *any* gravitational mass, meaning there is no Chandrasekhar limit in this argument. This implies a gradual increase in central density with mass, up to a point of neutronization, discussed next. Densities up to this range (around 10^{10} kg/m^3) then, seem to define white dwarfs.

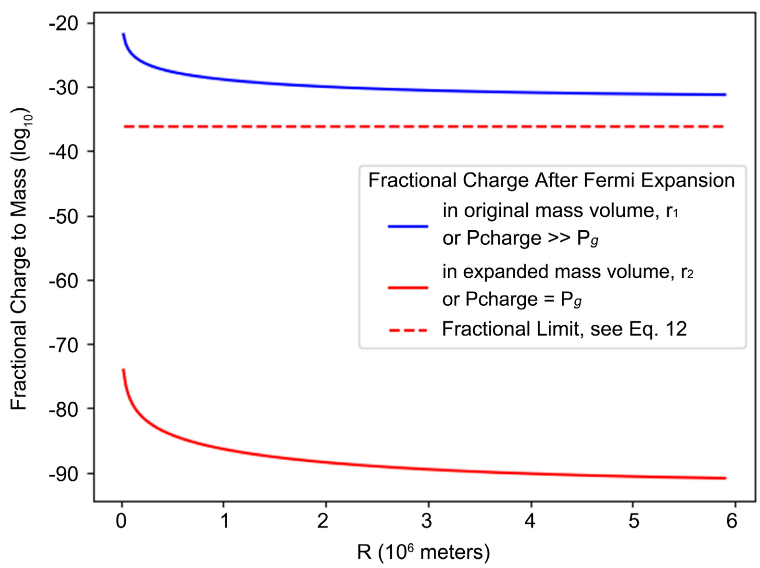

Figure 3. In a white dwarf, the positive fractional charge possible (blue) adapts to fractional charge needed (red) to support the mass. A star with charge under a limit (red dash) is stable ($\rho_c = 10^{10}$ kg/m^3).

7. Collapse

When the densities are greater than 10^{10} kg/m^3, the electrons become energetic enough to cause inverse beta decay (or neutronization), converting protons to neutrons. The converted material now has less charge to support the mass. The ensuing collapse is influenced by several factors.

Mass The mass of the star determines the increase in density and rate of conversion. This defines the process of the product, some form between a neutron star and an explosion. Lower mass stars with low conversion rates cause the material to collapse gradually into a neutron star. Larger mass stars with high conversion rates cause the material to collapse suddenly into an explosion.

Ions Neutronization will cause the ions to lose charge. Since the ions (the charge) support the mass, a sudden loss of charge results in a collapse. The "bottom" of the collapse is a higher density with less charge that would support the same mass. In a collapse, the ions are expected to overshoot this "bottom" (oscillatory).

Electrons The electrons at a number density high enough to produce inverse beta decay will soon deplete to a number density that will not, but never lower than our density limit of $\approx 10^{10}$ kg/m^3. In a collapse, the remaining electrons expand with number density relative to the ions, independent of the mass density. This separates the charge.

Charge Refer to Figure 3 (blue line), which is above the fractional limit (red dash). The result is a charge number of 5.4×10^{41} and an equivalent mass of 503 suns. This is an energy of 1.1×10^{49} Joules contained in an "earth" ($R = 6000$ km) or 3.3×10^{51} Joules contained in a neutron star ($R = 20$ km), well over the energy needed to explode.

The collapse will increase the density of the mass and the number density of the electrons. The electrons will expand, but the ions will not. Unlike the white dwarf, the collapse prevents the ions from following the electrons. The charge will separate enough to cause an explosion.

8. Discussion

There are several topics influenced by the mechanism described above:

Solar Systems As mentioned in the introduction, lower magnitude explosions have the ability to re-collapse. It is the core of heavy elements that explode, traveling through the hydrogen shell that did not participate in fusion. The cloud is produced (formatted) with the elements reversed, the iron now on the outside and the hydrogen on the inside. It is the hydrogen that will collapse first, followed by the iron (an iron rain), producing the solar system. We will examine this further in the argument on **Solar Systems**.

The Chandrasekhar limit This mass limit does not exist. It is a mathematical construct, not physical. It appears by using the degenerate electron pressure in the equation of hydrostatic equilibrium and/or the Lame Emden equation. Electron pressure does not support the mass of the star. Eddington rejected this limit (the collapse), but for some reason argued against electrons becoming relativistic [5].

Black Holes Black holes and neutron stars are not produced by this process. A core explosion removes all material from the core by defintion. Lower mass stars that collapse gradually are neutron heavy, but always supported by charge, not neutron degeneracy pressure, at least in the beginning. We discuss black holes further in the argument on **Stars**.

9. Conclusions

The argument presented shows a possible mechanism to produce a supernova. An important property of this mechanism is the elimination of the core after the explosion. This may lead to the formation of solar systems with the correct mass.

But to understand the formation of solar systems, we must understand the formation of stars. Stars, supernovas and probably galaxies are products of a collapsing cloud, depending on the mass of the cloud. Please read the argument on **Stars**, next.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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